Temporal Patterns of Angler Use and Abundance of Stocked 229-mm Channel Catfish in Twenty Small Texas Impoundments

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Abstract: Sub-adult channel catfish (*Ictalurus punctatus*) are stocked into community fishing lakes in Texas to provide anglers with the opportunity to catch fish close to home. Survival of these stocked fish is unknown, and this study was initiated to provide some information and guidance for the Texas Parks and Wildlife Department channel catfish stocking program. This study was conducted on 20 lakes in Texas between 0.4 and 4.0 ha with 10 located in urban environments and the other 10 in rural locations. Lakes were stocked one time with adipose fin-clipped channel catfish and surveyed monthly with baited hoop nets for 6 months. Angler effort was estimated using game cameras. Urban angling effort was significantly higher than rural angling effort. Winter had the lowest angling effort in rural and urban lakes, and angling effort declined significantly two weeks following stocking in both types of lakes. Hoop-net catch rate was similar between urban and rural lakes. Hoop-net sampling in five of the lakes yielded no recaptures of stocked channel catfish and stocked fish essentially disappeared within four months of stocking in five other lakes. Angling effort was lowest on lakes where stocked fish survived all six months (survival lakes); fishing effort was highest on lakes where stocked fish disappeared within the 6-mo target period (partial-survival lakes) indicating anglers may be removing these fish from the population. Angling effort on lakes where no channel catfish survived was intermediate and similar to effort in the survival and partial-survival lakes. The 229-mm channel catfish stocking program provided angler opportunity for at least six months in 50% of the stocked lakes in Texas and for less than six months in another 25%. Based on the results of this study, all lakes in the channel catfish stocking program are now evaluated for stocking success and those characterized by consistently high stocking mortality will be removed from the program.

Key words: *Ictalurus punctatus*, stocking efficacy, hoop net, fishing, survival

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Put-and-take fisheries, where catchable-sized fish are stocked and immediately available to anglers, are commonly used to provide increased fishing opportunities. One of the challenges of the put-and-take model is deciding how to partition limited resources to provide the greatest benefit to the most anglers. Stocking the appropriate number of fish is important for making efficient use of the fish and creating desirable fisheries (Michaletz 2009). If too few fish are stocked, the likelihood of catch may be so low that few anglers will participate (Alcorn 1981, Miko et al. 1995, Wickham et al. 2004). Understanding how anglers respond to stockings is crucial to assessing the benefit of these programs. Because the most influential factor determining whether or not someone fishes is if there are opportunities close to home (Patterson and Sullivan 2013), one strategy managers often use is to distribute the limited resource (in this case stocked fish) over numerous water bodies to benefit many local anglers.

The Texas Parks and Wildlife Department (TPWD) stocks advanced fingerling channel catfish (*Ictalurus punctatus*) as a cost-effective way of providing fish to the angling public (Eder and McDannold 1987, Michaletz and Dillard 1999, Michaletz et al. 2008, Munger 2012). Stocking catchable-size channel catfish incurs a substantial investment of time and money for production and delivery. For instance, TPWD stocked catchable-sized (i.e., approximately 229-mm total length [TL]) channel catfish into ≥250 community fishing lakes (CFLs) each year in 2013 and 2014 at costs of US$344,091 (112,642 fish) in 2013 and $684,623 (185,571 fish) in 2014 (T. Engeling, TPWD, personal communication). Thus, it is important that this program be operated as efficiently as possible to maximize benefits to anglers while minimizing costs.

The CFL channel catfish stocking program of TPWD is based

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on a simple put-and-take conceptual model that assumes stocking catchable-size fish will immediately create a fishery that attracts anglers and that stocking higher numbers of fish will attract even more anglers. This model further assumes that anglers will catch most of the fish and that angler catch rates affect the perception of the fishery by the angler (Patterson and Sullivan 2013). Given the small size (< 5 ha) of most Texas CFLs and the simple morphology of these systems, it is assumed that an angler's likelihood of catching a channel catfish is greater than would be expected in larger, more complex systems. This put-and-take strategy is an important element, as both Munger (2012) and Siegwarth and Johnson (1998) determined that stocked channel catfish composed over 90% of the total channel catfish population in small impoundments.

Even when sufficient numbers of fish are initially stocked, if survival of these stocked fish is low then angling opportunity will be diminished. High survival of stocked fish over time will extend their availability to anglers and presumably the opportunity to catch fish. Survival of channel catfish in small impoundments appears to be highly variable and has both natural and angling components. Natural mortality of stocked channel catfish was reported to be high (i.e., 55% during their first year; Storck and Newman 1988), very low (i.e., < 7%; Santucci et al. 1994), and highly variable (Munger 2012). Likewise, angler harvest of channel catfish in Alabama small impoundments was found to be highly variable, ranging from 0.99 to 767.90 fish ha^{-1} (Shaner et al. 1996), whereas Santucci et al. (1994) reported high angler harvest in Illinois lakes with 52%–92% of stocked channel catfish > 200 mm TL being harvested within one year. The size and number of stocked channel catfish can impact post-stocking survival of fish which often relates to the relative success of the put-and-take stocking strategy (Eder and McDannold 1987, Shaner et al. 1996). Stocking channel catfish longer than 200 mm TL results in increased survival (Storck and Newman 1988, Howell and Betsill 1999) and return to anglers (Storck and Newman 1988). Therefore, it is important to understand not only how anglers respond to stocking, but how long fish are available to anglers.

For Texas, one major challenge is how to partition resources between rural and urban anglers. While human population densities are higher in urban areas, fishing effort may not be correlated with that density. Munger (2012) reported that angling pressure was similar on an urban CFL (913.6 h mo^{-1}) and a rural CFL (932.1 h mo^{-1}). Chizinski (2012) expected higher exploitation in lakes located near human population centers or easily accessed state recreation areas, but found that relationship was not always reflected in creel surveys. Further, angler motivations may differ, altering the overall survival of stocked fish. Surveys conducted more than 30 years ago showed that urban anglers were more likely to be interested in harvest than recreation (Alcorn 1981, Ditton and Fedler 1984, Manfredo et al. 1984) but more recent studies indicate a higher percentage focused on the recreational and social aspect of fishing rather than harvest (Schramm and Dennis 1993, Hutt and Jackson 2008, Mahasuweerachai et al. 2010). Angler behavior may be different even among lakes that would be categorized as rural. Anglers who fished Pony Express Lake, Missouri, released very few of their catfish (Eder and McDannold 1987); whereas all catfish caught at Canyon Southeast Park Lake, Texas, were released (Munger 2012). Understanding the differences in effort between urban and rural sites may allow fisheries managers to better allocate stocked channel catfish.

The goal of this study was to verify the assumption that the TPWD CFL channel catfish stocking program is providing opportunity to catch channel catfish for anglers using these fisheries. This study was conducted on 20 small CFLs in both urban and rural settings throughout Texas. The specific objectives of this study were to 1) estimate angler effort associated with stocked channel catfish in CFLs, 2) test whether angler use differs between rural and urban settings, and 3) estimate how long stocked channel catfish are available to anglers in the CFLs. For the purposes of this study, any documented population of channel catfish remaining more than six months after stocking was deemed a successful stocking. The results of this study will provide baseline data on stocked channel catfish survival in a variety of CFLs across Texas, information on angler use of the resource, and inform TPWD concerning future stocking and management of CFLs.

Methods

Study Sites and Stocking Procedures

The study was conducted on 20 CFLs between 0.4 and 4.0 ha distributed throughout Texas. Ten of the lakes were located in urban environments and the other 10 in rural locations. We considered an urban environment to be equivalent to the U. S. Census Bureau definition of a metropolitan area, with a core urban area population ≥50,000, within one or more counties, and any adjacent areas that have a high degree of social and economic integration. A rural lake was defined as being located anywhere that is not an urban area.

Each lake was stocked with adipose fin-clipped (McFarlane et al. 1990) channel catfish in late October or early November 2013. The short time frame for this study and complete removal of the fin reduced the risk of regrowth of the adipose fin in instances where removal was not complete (Wydoski and Emery 1983, Nielsen 1992). Because we were evaluating success of the normal CFL channel catfish stocking conducted by TPWD, this study used the normal TPWD stocking request process and formula, and standard stocking procedures. Stocking rates were determined by a log-linear equation used by TPWD to determine CFL channel catfish stocking rates: $n = 400A^{-0.70874}$, where A was the surface area of the lake in acres and

N was the number of fish stocked per acre. Thus, stocking rates for lakes in this study decreased from 988 fish ha^{-1} to 249 fish ha^{-1} as CFL area increased from 0.4 to 4.0 ha. Study fish were fin clipped by TPWD staff as they were sorted in raceways prior to stocking, and stocking was conducted according to standard TPWD procedures.

Angler Data

Angler counts were conducted using digital game cameras with methods patterned after those described in Patterson and Sullivan (2013). Cameras were placed in secure locations near each lake, close enough to accurately determine angling activity and covering as much of the lake as possible. If multiple cameras were used on a single lake, efforts were made to minimize overlap of photographs to reduce the risk of double counting anglers. When multiple cameras were used, counts from all cameras were combined to develop a single angler count for each hour.

Game cameras were programmed to record images once every hour from daylight to dark. Hunt and Ditton (1996) determined that most fishing trips to CFLs in Texas lasted 4 h, so we believe the 1-h photo interval was sufficient to allow estimation of angler use of the resource. The number of daily counts and start times for each daily count were derived from the TPWD standard creel survey day-length table (TPWD unpublished survey procedures). Photo recording began approximately one week prior to stocking and continued through 31 August 2014. Photographs were reviewed each month by district staff and the total number of anglers fishing each hour of each day was recorded as an estimate of angler effort for that hour. If an angler was counted within an hour, that angler was counted as fishing for one full hour. Angler counts for each lake were summed by hour, day, and month as estimates of angling effort for each time period.

Total angling effort (angler-h) was estimated at each lake and used to evaluate differences between urban and rural lakes and to see if effort changed relative to the stocking event and season. Seasons were defined as winter (December–February), spring (March–May), summer (June–August), and fall (September–November). Fall data were not analyzed further due to low sample sizes. To test differences in angling effort among lake type and season, ANOVA-type statistics were performed using package nparLD in R software (Kimihiro et al. 2012). A post hoc Pairwise Wilcox test with a Bonferroni correction was used to identify the differences reported in the nparLD ANOVA procedure.

Stocking effect on angling was determined by ANOVA using average angler counts for stocking weeks and post-stocking weeks. Stocking weeks were the first full week following stocking and the week immediately following. Post-stocking weeks were defined as the fourth and fifth weeks after the actual stocking week.

Hoop Net Data

Abundance data for stocked channel catfish were collected using baited, small-diameter hoop nets. Hoop-net surveys commenced two weeks following the initial stocking and were conducted monthly through May 2014. Hoop nets are commonly used to collect channel catfish in lakes (Sullivan and Gale 1999, Michaletz and Sullivan 2002, Flammang and Schultz 2007, Buckmeier and Schlechte 2009). Baited hoop nets are more efficient in small lakes (Wallace et al. 2011, Chizinski 2012) and have been shown to sample channel catfish in proportion to their abundance without size bias (Yeh 1977, Buckmeier and Schlechte 2009).

Hoop nets used in this study had five 61-cm inside diameter fiberglass hoops with throats tied to the first and third hoops, were approximately 3-m long, and were constructed of 2.54-cm bar mesh (Munger 2012). Hoop nets were fished as sets of three nets tied in tandem (Walker et al. 1994, Sullivan and Gale 1999, Michaletz and Sullivan 2002, Flammang and Schultz 2007, Wallace et al. 2011). The three nets were connected mouth to cod end with approximately 1-m of lead between adjacent nets and were considered a single unit of effort.

Hoop nets were fished undisturbed for two consecutive nights as described in Neely and Dumont (2011). Each hoop net was baited with approximately one third of a commercially available cheese log (Gerhardt and Hubert 1989), which was placed in a mesh bag and attached to the hoop nearest the cod end of each net. The small size of study lakes limited the possible number of random sampling locations, so fixed sampling sites were used. Since sampling was conducted on urban lakes where human interference was expected to occur, all sampling locations were selected to reduce possible incidence of snagging by anglers and nets were set in water at least 1.5 m deep. Evidence of high traffic along shoreline areas was used to determine locations that should be avoided. Net floats were designed to be inconspicuous to reduce disturbance by anglers or other lake users.

Each lake was sampled with two hoop-net sets at 1-mo intervals beginning within two weeks of stocking and continuing through May 2014. When nets were retrieved, channel catfish data were combined from all three nets in the set and recorded as total catch net-set^{-1}. All channel catfish were counted, inspected for fin clips, measured (TL, mm), weighed (g), and then returned to the lake.

Hoop-net catch-per-unit-effort (CPUE) was calculated for each lake by month and used to indicate channel catfish availability to area anglers. Flammang and Schultz (2007) showed that catch across seasons was similar within impoundments and therefore we considered it to provide an indicator of persistence in the CFL. Catch rates were calculated by averaging the CPUE of the two sets per sample. The relationship between hoop-net CPUE and angler effort and hoop-net CPUE and stocking rate was tested using correlation analysis. Differences in hoop-net CPUE by lake type were tested using ANOVA. A significance level of a $P \le 0.05$ was used for all tests. Statistics were calculated with program R and SAS plug-in for Excel. Outlier lakes for angler-count or hoop-net data were identified using the extreme studentized deviate test (Grubb 1969), and if found, were removed from analyses of that particular dataset.

Stocking Success

Lakes were assigned into three different stocking success categories. Lakes where no stocked channel catfish were recaptured were categorized as unsuccessful. Lakes where marked channel catfish were initially recaptured but were no longer captured after six months were placed into a partial success group. Lakes that had stocked channel catfish recaptured through the sample period were considered successfully stocked. Mean stocking rate, angler effort, and hoop-net catch rate were examined across these categories using an ANOVA, as described above. Post hoc Bonferroni (Dunn) t-tests for count ($P > 0.05$) were conducted on angler effort based on stocking success category. Furthermore, mean hoop-net catch rate was examined through time across success categories.

Results

Angler Data

One urban lake was removed from angler-count analysis due to multiple camera issues and another was determined to be an outlier and removed from the angler analysis. A total of 16,722 angler h were recorded at 18 CFLs between 30 September 2013 and 31 August 2014 with 11,068 h occurring on urban lakes (Table 1). Angler effort was consistently higher on urban lakes than rural lakes throughout the study (Figure 1), and overall mean effort was likewise higher on urban lakes ($F = 5.55$, df = 1, $P = 0.02$) (Table 1). Angler effort was lower in winter than in spring or summer ($F = 33.65$, df = 1.85, $P < 0.01$) (Table 2), and no significant interactions were observed between lake type and season ($F = 0.79$, df = 1.85, $P = 0.44$). Seasonal pressure for urban lakes peaked during spring, whereas effort on rural lakes peaked in summer (Table 2). Angler effort during stocking weeks (Figure 2) was significantly higher than post-stocking weeks for all lakes combined ($F = 65.12$, df = 3, $P = 0.02$) and urban lakes ($F = 237.32$, df = 3, $P = 0.04$) but not for rural lakes ($F = 2.47$, df = 3, $P = 0.26$). There was no significant relationship between stocking rate and average angling effort ($F = 2.28$, df = 35, $P = 0.14$).

Hoop Net Data

Overall hoop-net CPUE was 4.6 fish net-set^{-1} (SD = 10.7) over all lakes (Table 3). Hoop-net CPUE was 2.5 fish net-set^{-1} (SD = 6.0) and 6.8 fish net-set^{-1} (SD = 13.9) for urban and rural lakes, re-

Table 1. Total angler h, mean monthly angling effort, SD, and range of monthly angling effort by lake type for 18 community fishing lakes in Texas from October 2013–May 2014. Means with the same superscript were similar (pairwise Wilcox test with a Bonferroni correction, $P > 0.05$).

Type	*n*	Total angler h	Mean effort (angler h)	SD	Range (angler h)
All lakes	18	16,722	91.4	128.8	0–1029
Urban lakes	9	11,068	119.5^a	151.87	7–1029
Rural lakes	9	5654	62.8^b	92.03	0–484

Table 2. Mean angling effort (angler h) by season and lake type (SD) for 18 community fishing lakes (nine urban and nine rural) in Texas from October 2013–May 2014. Means with the same superscript were similar within the same lake type (pairwise Wilcox test with a Bonferroni correction, $P > 0.05$). Fall was not analyzed due to incomplete data and small sample size.

Type	Fall (Oct–Nov)	Winter (Dec–Feb)	Spring (Mar–May)	Summer (Jun–Aug)
All lakes	88.7 (196.6)	30.0^a (26.9)	124.4^b (138.3)	122.2^b (119.3)
Urban lakes	133.6 (262.3)	41.4^a (27.5)	171.6^b (157.9)	137.8^b (113.7)
Rural lakes	36.4 (30.9)	18.1^a (20.7)	77.1^b (97.0)	106.6^b (124.8)

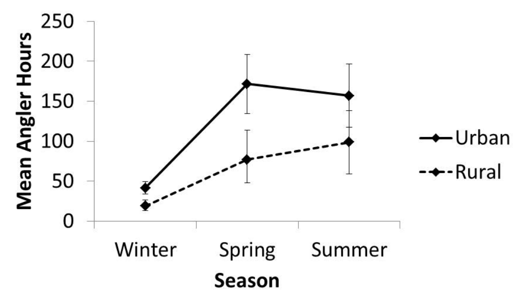

Figure 1. Mean seasonal angler effort (angler-h) between urban and rural lakes stocked with marked channel catfish in Texas. Vertical bars indicate standard error.

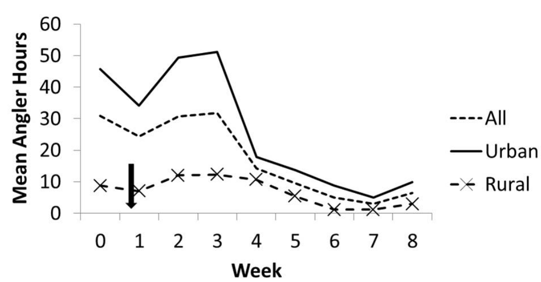

Figure 2. Mean weekly angler effort (angler-h) for nine urban and nine rural lakes in Texas following stocking. Stocking was conducted during week one indicated by the vertical arrow.

Table 3. Name, type, area, channel catfish stocking rate, mean hoop-net catch-per-unit-effort (CPUE), and percentage of catfish caught in hoop nets that were stocked for 20 community fishing lakes in Texas from October 2013–May 2014.

Name	Type	ha	Stocking rate (fish ha^{-1})	CPUE (SD) (fish net-set^{-1})	% Stocked
Abernathy	Rural	1.6	374.7	10.1 (14.06)	87.1
Davidson	Rural	0.8	606.2	0.6 (0.61)	53.8
Frio	Rural	1.5	1108.5	0.8 (0.71)	42.9
Lester	Rural	0.8	1225.7	0.2 (0.26)	100.0
Little Chocolate	Rural	1.6	374.1	14.1 (10.29)	78.5
Winchester	Rural	1.0	605.4	35.6 (18.84)	100.0
Atlanta	Rural	0.8	614.8	0.0	
Karrh	Rural	0.4	990.1	0.0	
Bridge Bob's	Rural	0.5	604.9	0.0	
Knierim	Rural	1.2	473.3	0.0	
Bethany	Urban	1.2	454.3	1.3 (1.94)	34.7
Cal Young	Urban	2.4	277.4	0.3 (0.39)	14.7
Cy Miller	Urban	0.4	1014.8	3.9 (4.56)	100.0
Earl Scott	Urban	0.9	646.7	0.2 (0.37)	100.0
Harvey	Urban	0.4	987.7	2.1 (1.48)	100.0
Houston-Harte	Urban	2.0	321.0	5.2 (5.76)	61.5
Huneke	Urban	1.4	440.1	6.5 (15.49)	95.8
Kennedale	Urban	1.3	419.4	1.4 (3.13)	100.0
Optimist	Urban	0.8	496.3	0.9 (0.69)	93.3
Russell Creek	Urban	2.8	249.4	0.0	
All Lakes		1.2 (0.7)	614.2 (293.4)	4.6 (10.7)	77.5 (28.7)
Urban Lakes		1.4 (0.8)	530.7 (273.2)	2.5 (6.0)	77.7 (29.4)
Rural Lakes		1.0 (0.5)	697.8 (302.7)	6.8 (13.9)	77.0 (23.9)

Table 4. Number, mean weekly angling effort (h), range of weekly angler effort (h), median weekly angler effort (h), and mean hoop-net catch-per-unit-effort (CPUE; fish net-set^{-1}) by stocking success category for 18 community fishing lakes in Texas from 14 October 2013–30 August 2014. Means with the same superscript were similar (post hoc Bonferroni (Dunn) t-tests for count data, $P > 0.05$). Standard deviation is presented in parentheses.

Type	*n*	Mean angler effort	Angler effort range	Median angler effort	Mean hoop-net CPUE
Successful	9	15.8^{B} (11.5)	0–222	13.6	6.9 (12.7)
Partial success	4	30.6^{A} (22.3)	0–308	32.3	3.3 (9.2)
Unsuccessful	5	22.7A^{B} (15.8)	0–145	20.3	0.0

spectively, but were not significantly different ($F=1.14$, df = 19, $P=0.30$). Five of the lakes had no recaptures of stocked fish. When those lakes were removed from analysis, the rural average CPUE became 10.3 fish net-set^{-1} (SD = 16.0) and the urban average CPUE 2.7 fish net-set^{-1} (SD = 6.2). There was no correlation between stocking rate and hoop-net CPUE ($r^2=0.02$, $P=0.52$) or between hoop-net CPUE and angler effort for all lakes combined ($r^2<0.01$, $P=0.79$), urban lakes ($r^2=0.02$, $P=0.75$) or rural lakes ($r^2<0.01$, $P=0.81$). There were no correlations among stocking rate, hoop net catch, or angler effort across lakes or lake type ($P \geq 0.52$).

Stocking Success

Channel catfish were never recaptured in four rural lakes and one urban lake and stocking was considered unsuccessful (Table 3). Stocking was partially successful in two rural and three urban lakes. Channel catfish were recaptured throughout the 6-mo sampling period in the remaining ten lakes (four rural and six urban). Mean stocking rate did not vary across stocking success categories ($F=0.54$, df = 17, $P=0.59$).

Analysis of angling effort categorized by success showed significant differences among groups (Table 4). Angling effort in the partial success group (mean, 30.6 h wk^{-1}, SD = 22.3) was similar to what was observed in the unsuccessful group (mean, 22.7 h wk^{-1}, SD = 15.8) but was higher than effort in the success group (mean, 15.8 h wk^{-1}, SD = 11.5; $F=8.65$, df = 135, $P<0.01$). For all lake types, it was observed that abundance of stocked channel catfish declined through time (Figure 3). Mean hoop-net CPUE in the partial success group declined from a group average of 16.1 set^{-1} (SD = 19.2) in November to 0.6 set^{-1} (SD = 0.8) by January. Five of 10 lakes in the success group had either stable or increasing CPUE of stocked channel catfish while the other five showed declining CPUE.

Discussion

Stocking events can directly affect the behavior of anglers, resulting in increased effort and harvest immediately following stocking. Alcorn (1981) found that fluctuations in the number of fish caught was closely related to fish stocking dates with the

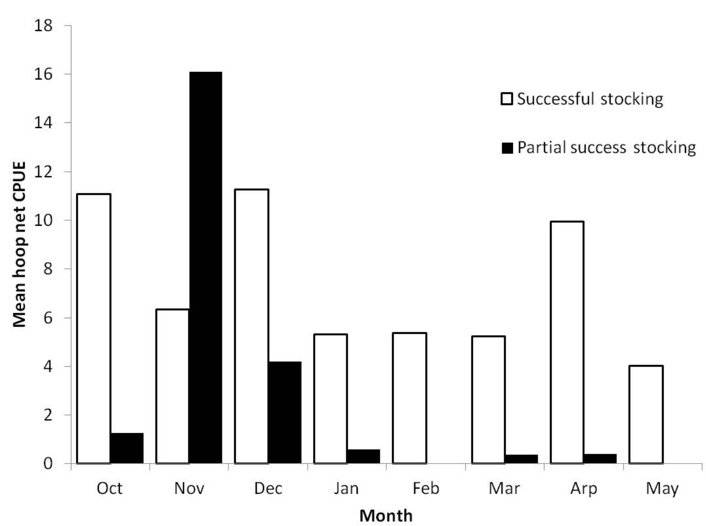

Figure 3. Mean monthly hoop net CPUE (fish net-set^{-1}) for 10 lakes categorized as successfully stocked and five lakes categorized as partially successfully stocked with channel catfish in Texas community fishing lakes.

highest catch rates observed for only a few days following stocking. Howell et al. (2008) reported that 25% of stocked fish were harvested within six days of stocking and that there was high angling pressure for a few days post stocking followed by a 50%–70% decline in angling effort within a week. Similarly, angling effort during the stocking period (first two full weeks following) in Texas CFLs was higher than effort during the fourth and fifth full weeks following stocking for all lakes combined and urban lakes but not for rural lakes.

Most TPWD CFL channel catfish stocking events are not advertised to the public. For our study, District biologists were asked to conduct these stockings normally, including whether advertising by mass media or Facebook was or was not done. Stocking was only advertised at three of the study locations (two urban and one rural), all of which occurred post stocking, so there was likely limited advertising influence on angler effort during the stocking week. City officials were notified of the stockings at over half of the study locations either just before or immediately after the stocking event, and these stockings were sometimes mentioned by TPWD biologists during conversations with anglers. The notifications and conversation may have caused increased angler use immediately around the stocking event, particularly in the urban areas. Word of mouth has been shown to be an effective method of transmitting information, especially within distinct social networks (Buttle 1998, Duan et al. 2008). This should also be true among social networks of individuals who identify as anglers. Ellison and Fudenberg (1995) found that the size of the network influenced the efficiency of information transfer with larger numbers transferring information more efficiently, which may explain why the stocking effect was seen in the urban areas but not in the rural areas.

Angling effort declined during the week of stocking for both rural and urban lakes. Thus, angling effort may have been high prior to stocking, and seasonal weather changes soon afterwards reduced angling effort to winter levels. Patterns of angler behavior observed during this study were likely dictated by both seasonal weather and timing of the stockings, but our data was insufficient to quantify or evaluate the impact of either phenomenon on angler use of the CFLs.

When channel catfish are stocked into a CFL, the objective is to provide anglers an opportunity to catch fish. Thus the fate of stocked fish in these lakes directly impacts amount of fishing opportunity provided to the anglers. The stated definition of a successful stocking within this study was to have at least some of the fish still available to anglers six months after stocking. Stocked channel catfish disappeared soon after stocking in 25% of the study lakes and survived for less than the target six-month period in another 25% of the lakes. Thus, the program was only successful in meeting its stated six-month goal in only 50% of the study lakes. Hoop-net data from these successfully-stocked lakes indicated that, on average, approximately 60% of the stocked channel catfish remained in the lake by the end of six months. Disappearance of stocked channel catfish from CFLs may not indicate failure, as it could be due to harvest and not natural mortality. Obviously, if the fish are being lost to harvest, then the goals of this program are still being met. Anglers that use urban fishing lakes are often described as being more harvest oriented (Alcorn 1981, Manfredo et al. 1984), but Munger (2012) found that anglers did not harvest any channel catfish in two Texas urban CFLs. Michaletz and Stanovick (2005) stated that angler harvest of channel catfish increased with angling effort, so higher angler counts determined by game cameras could be assumed to represent higher harvest by anglers.

Mean and maximum weekly angler effort was higher on partial-survival CFLs than survival CFLs, but effort in the unsuccessful CFLs was intermediate and similar to the other types. Further, stocked channel catfish disappeared immediately in all of the unsuccessful lakes and disappeared within four months after stocking in 40% of the partial success lakes during seasons when angler effort was the lowest. While Alcorn (1981) and Howell et al. (2008) found that stocked fish can be quickly removed, Michaletz and Stanovick (2005) related harvest with angling effort, thus lower angler counts should indicate low harvest. Michaletz et al. (2008) found that just a few anglers can be a major source of exploitation in small impoundments, so the few anglers we observed at some of the CFLs could have had a large impact on the channel catfish population. But this does not explain why would there be an impact on only 25% of the lakes when it would be logical to assume that an equal percentage of high impact anglers would exist in any angling population. While the angler data collected in this study does implicate harvest as a factor, it does not fully answer the question of what happens to stocked channel catfish in Texas lakes. Further study will be needed to determine if the fish are actually being removed by anglers or by some other type of mortality.

Management Implications

Results from this study were used to evaluate whether the TPWD CFL channel catfish stocking program is meeting TPWD goals by providing sustained angler opportunity. Based on the information obtained in this study and through literature review, four options were considered regarding the TPWD CFL channel catfish stocking program.

Option 1: Continue the stocking program in its current format.— Fisheries management agencies are interested in increasing their user base of annual fishing license buyers and stocking can be used as a proactive tool to attract new anglers (Martin and Pope

2011). If anglers are attracted to a lake by stocking, they may then be more likely to continue to purchase a fishing license. Stocking can also be used to manage angler expectations and encourage use regardless of angling success and could improve angler attitudes about the resource and management agency (Buynak et al. 1999). While the current stocking program is expensive, this study indicated that stocked channel catfish had enough survival in 50% of CFLs to provide fishing opportunity for at least six months post stocking. Additionally, channel catfish stocking survival was high enough in another 25% of CFL to provide shorter term opportunities.

Option 2: Discontinue the TPWD CFL channel catfish stocking program.—A complete cessation of the stocking program would be a cost saving to TPWD, but could have a strong negative effect on angler attitudes about fishing and TPWD (Alcorn 1981). While there would likely be negative perceptions from anglers, Schramm and Edwards (1994) suggested that managers should challenge angler beliefs that stocking is necessary to maintain high-effort fisheries. By discontinuing stocking, TPWD could be taking a step toward effective aquatic education efforts that lead anglers away from the idea that good fishing is simply a result of putting fish in the water.

Option 3: Modify the current stocking program to increase survival of the fish.—Survival of stocked channel catfish in Texas CFLs has been lower than desired. Biologists have experimented with changing the size of fish stocked (Storck and Newman 1988, Walters et al. 1997, Michaletz et al. 2008), stocking season (Gunn et al. 1987, Elrod and Schneider 1992), stocking technique (Elrod and Schneider 1992), and strain of fish (Yule et al. 2000) in an effort to improve survival and return to anglers. Elrod and Schneider (1992) found no difference in lake trout survival among three different stocking techniques. Survival of stocked trout (Gunn et al. 1987, Elrod and Schneider 1992) has been found to be unaffected by season; however, Yule et al. (2000) reported that fall stocking of trout improved survival over spring stocking.

Shifting channel catfish stockings to spring might match angler-use patterns more closely, so fish would be available when anglers are most likely to fish for them. Costs associated with spring stocking would include longer feed and staff time to hold the fish over winter and possibly reduced stocking survival related to increased hatchery residence time as observed for trout by Gunn et al. (1987). Increasing the size of stocked channel catfish is possible, but may not result in higher survival or increase availability of fish, as larger size at stocking mm may only increase exploitation, resulting in faster removal by anglers (Walters et al. 1987, Michaletz et al. 2008).

Genetic strain of stocked fish can sometimes dictate survival (Yule et al. 2000). Texas hatcheries rely primarily on the imperial strain of channel catfish which was developed in 1977 in Uvalde, Texas (Dunham and Smitherman 1984). Dumont (2005), found that this strain did not outperform wild-caught offspring in reservoirs, and in some situations the wild-caught offspring appeared to be healthier. Thus, the potential that a different strain of channel catfish may survive better under conditions typically seen in Texas CFLs should be investigated.

Option 4: Modify the lake selection process and stocking rates.—Modifying the lake selection process could involve developing specific survival or angling criteria that would be used to select lakes to be stocked with channel catfish. A quarter of the stocked lakes in this study had no measureable return from stocking. If stocking was ceased at lakes where survival is minimal, the hatchery system could save a considerable amount of money due to reduced demand from district managers. Modifying the lake selection process would require development of specific stocking criteria for community lakes that could include demonstrated stocking survival for at least 60% of stocking events or documenting angler harvest of fish for some time period following stocking. Criteria should include standards that allow for variable survival based on weather or transportation issues. This option would require a significant amount of additional sampling effort to fully evaluate stocking at all community lakes in the state and would need to be phased in over a number of years. Stocking rates could also be modified based on angler use. This study found no correlation between stocking rate and hoop-net CPUE or angler effort, similar to what has been observed in other studies (Miko et al. 1995, Michaletz and Stanovick 2005), but stocking rates for CFLs with low angler effort could be reduced.

After reviewing these options, TPWD decided to apply elements of both option 3 and option 4 to the CFL channel catfish stocking program. Since completion of this study, all stocking events are now evaluated for survival of stocked fish and locations with consistently high mortality will be removed from the stocking program. Survival of stocked fish will be documented either through fisheries surveys or fishing records. Survival of channel catfish stocked during spring will be evaluated to determine if survival and return to anglers is improved.

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